Embedded Life-Cycle Management for Smart Multimaterials Structures: Application to Engine Components

Process Simulation

Simulation

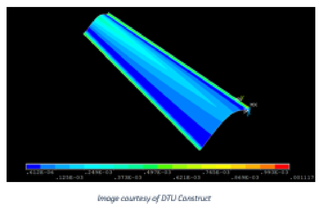
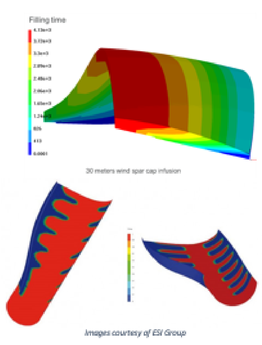


Image courtesy of DTU Construct

- What ?
  - Numerical simulation combined with sensor data
  - Used to minimise defect formation by:
    - Defining the manufacturing processes
    - Understanding how the process should be modified in real-time in response to *in situ* monitoring data
- How ?
  - Multi-scale modelling of the manufacturing process
    - From virtual characterisation of the local material properties to high fidelity analysis of the manufacturing of the blade
  - Exploring the field of possibilities in real time
    - By the combination of advanced AI techniques (model order reduction, machine learning *etc.*)
  - Generating physical-based prediction in a decision support system for the production hybrid sensor

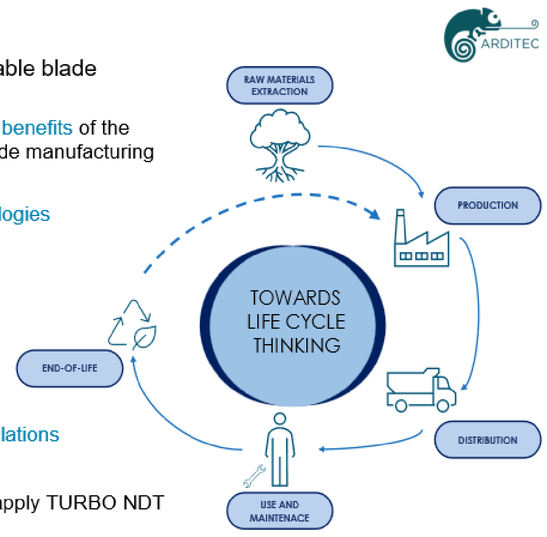


Images courtesy of ESI Group

Sustainability assessment

Sustainability assessments

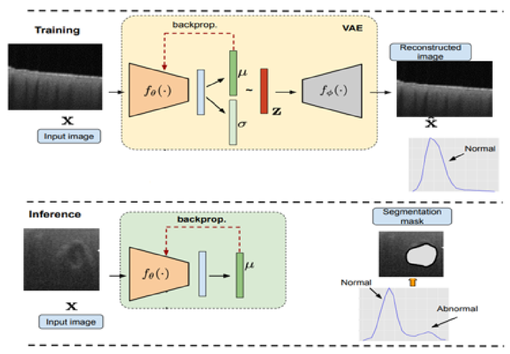
- Arditec will help to develop circular and sustainable blade manufacturing by:
  - Assessing the environmental, economic and social benefits of the innovative value chain in comparison to current blade manufacturing processes
  - Using standardised life cycle assessment methodologies
    - LCA (ISO 14040/14044)
    - Life Cycle Costing (LCC, ISO, 2006)
    - Social LCA (UNEP/SETAC)
  - Developing circular pathways for production waste
    - Material Circularity Indicator (MCI) methodology developed by the Ellen MacArthur Foundation
  - Contributing to current relevant standards and regulations
    - IEC 61400-5/IEC 61400-28-2/REACH
  - Training SGRE personnel to operate the sensors, apply TURBO NDT methods and interpret the results



Machine Learning

Machine learning analysis for NDT of blade coatings

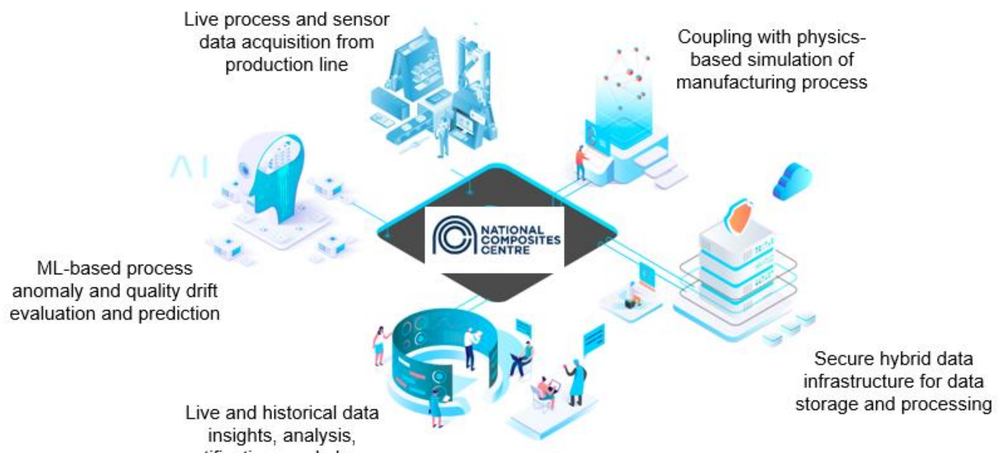
- DTU will develop a supercontinuum extending to longer mid-IR wavelengths (***e.g.*** 4 µm)
  - These wavelengths penetrate deeper than traditional near-IR OCT systems (typically 1.3 µm)
  - Source is based on a 2 µm laser to pump ZBLAN fibre
- UPV will develop machine learning based algorithms
  - Unsupervised anomaly detection techniques
  - Used to detect and segment different defects in OCT images without annotations



Constrained unsupervised anomaly classification and segmentation

Digital platform

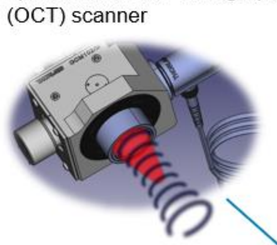
TURBO digital overview



NDT surface inspection

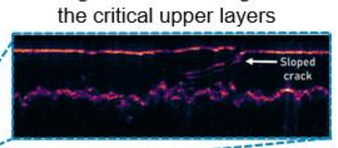
NDT of blade coatings

- First industrial-scale combined thermography and mid-IR optical coherence tomography (OCT) scanner



- Deep penetration of thermography combined with new technology of mid-IR OCT
- For *sub-surface* defect detection

- High resolution images of the critical upper layers



- Demonstrated on ship hulls

Petersen, Christian R., *et al.* "Non-destructive subsurface inspection of marine and protective coatings using near-and mid-infrared optical coherence tomography." Coatings **11**: 877 (2021).

Digital twin framework

TURBO digital twin framework

- NCC will develop a self-adaptive manufacturing process
  - Digital framework for zero waste wind turbine blade manufacturing
- Key steps:
  - Scale-up of manufacturing and simulation to a full scale blade demonstrator
  - Combine process and sensor data with machine learning and physics-based simulations
  - Provide live manufacturing quality insights and corrective feedback loop control
  - Development of a secure digital twin architecture scalable for industrial production environments

Partners

DTU · NORBLIS Nordic Broadband Light Solutions · esi get it right · ARDITEC · synthesites · National Composites Centre · cpi · Vivid Components · Universitat Politècnica de València · Siemens Gamesa Renewable Energy

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